

Solving industrial design problems by using COMSOL Multiphysics with MATLAB

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Part III: MATLAB

Conclusions

- **Industrial examples**
 - Microfluidic mixer
 - Toy problem
- **COMSOL Multiphysics**
 - Creation of the model
 - Conversion to MATLAB
- **MATLAB**
 - Structure of the M-script
 - Useful commands
 - Creating a function
- **Conclusions**

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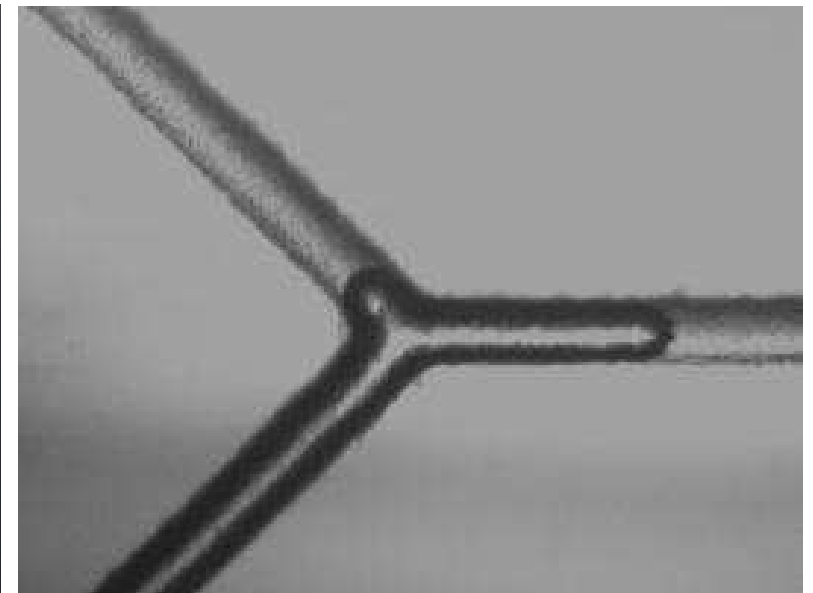
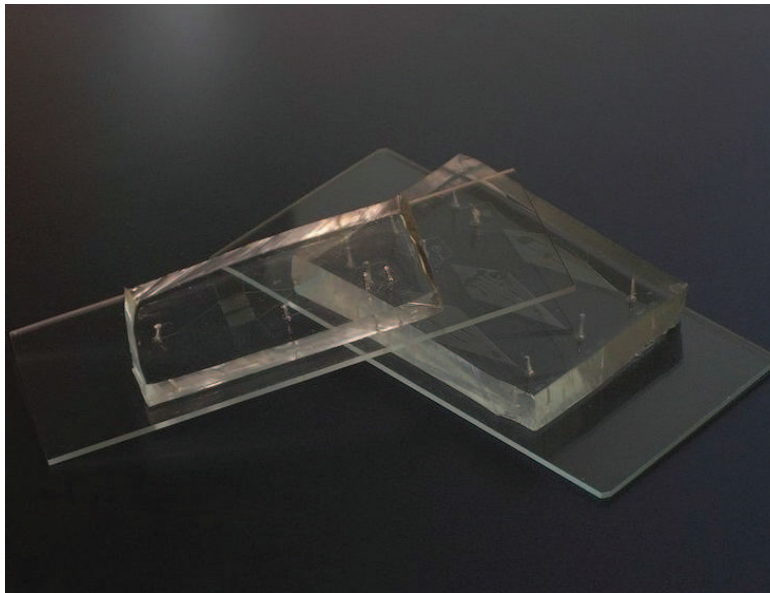
Conclusions

Part I: Industrial examples

Device: Microfluidic mixer

Application: Microfluidic mixers are used to quickly mix a protein solution with a solvent provoking a **rapid change** in chemical potential resulting in the unfold of certain proteins.

Example of microfluidic mixer: There exist a **wide range** of techniques to create microfluidic mixers. For instance:



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Industrial problem

Objective: optimize the mixer to **reduce the time** needed to reach a certain protein concentration.

Considered mixer: **Knight** mixer

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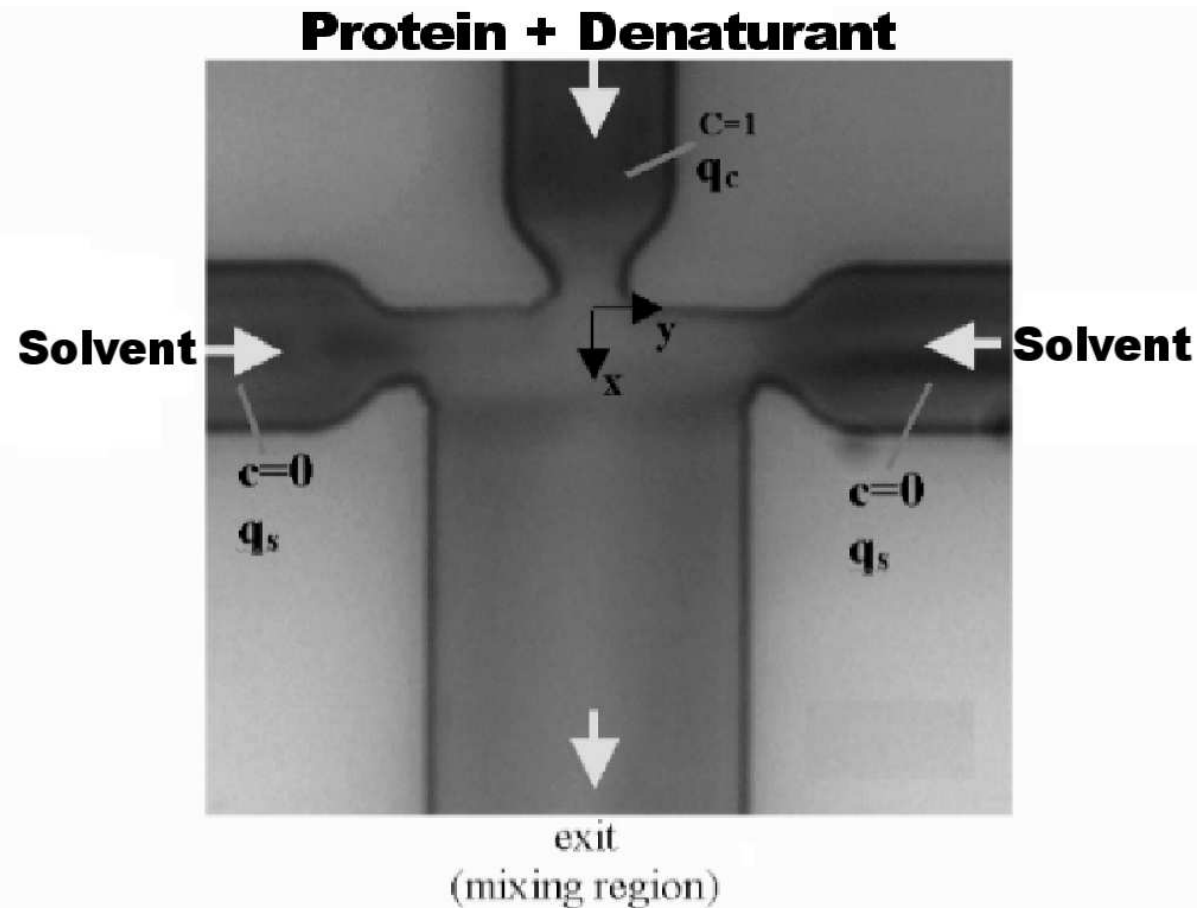
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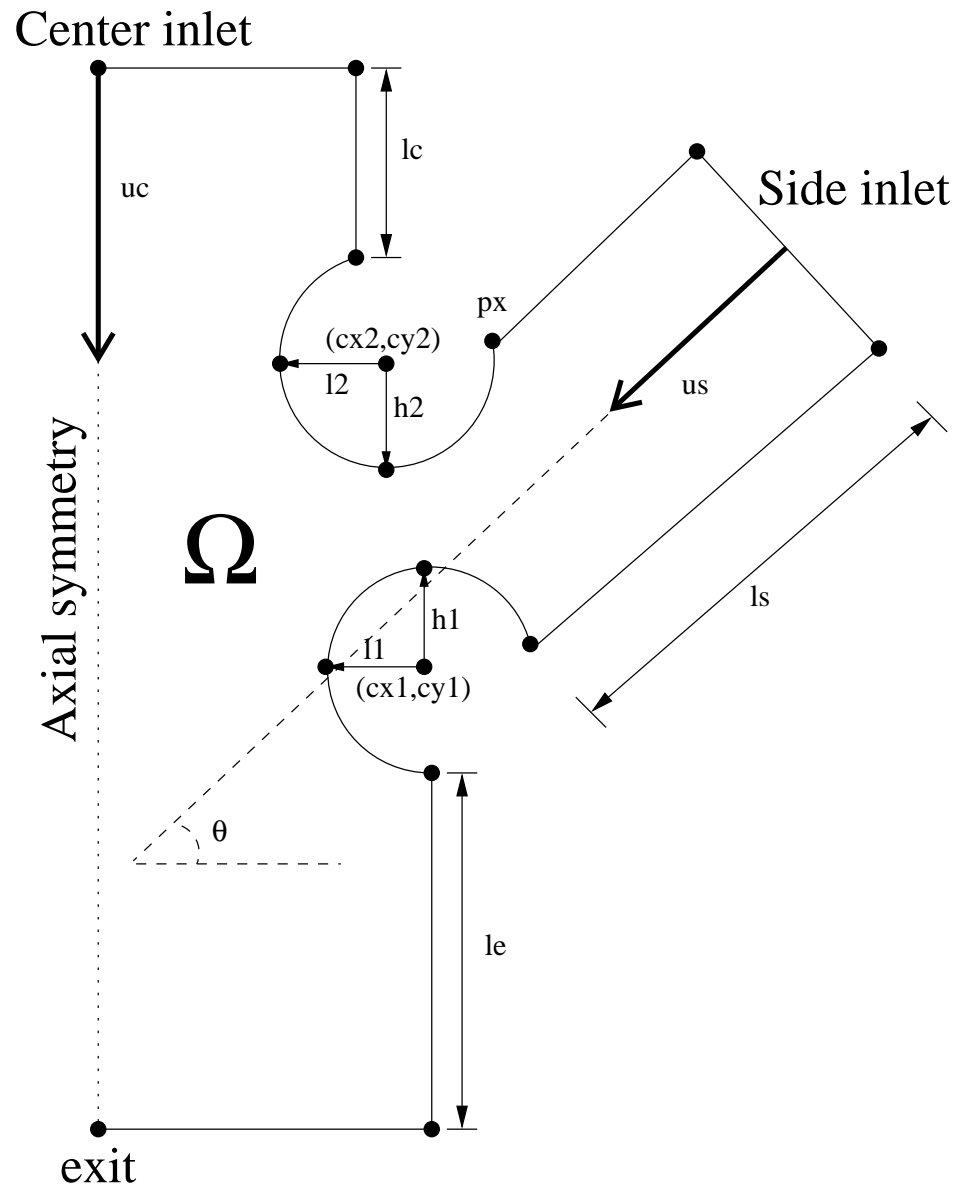
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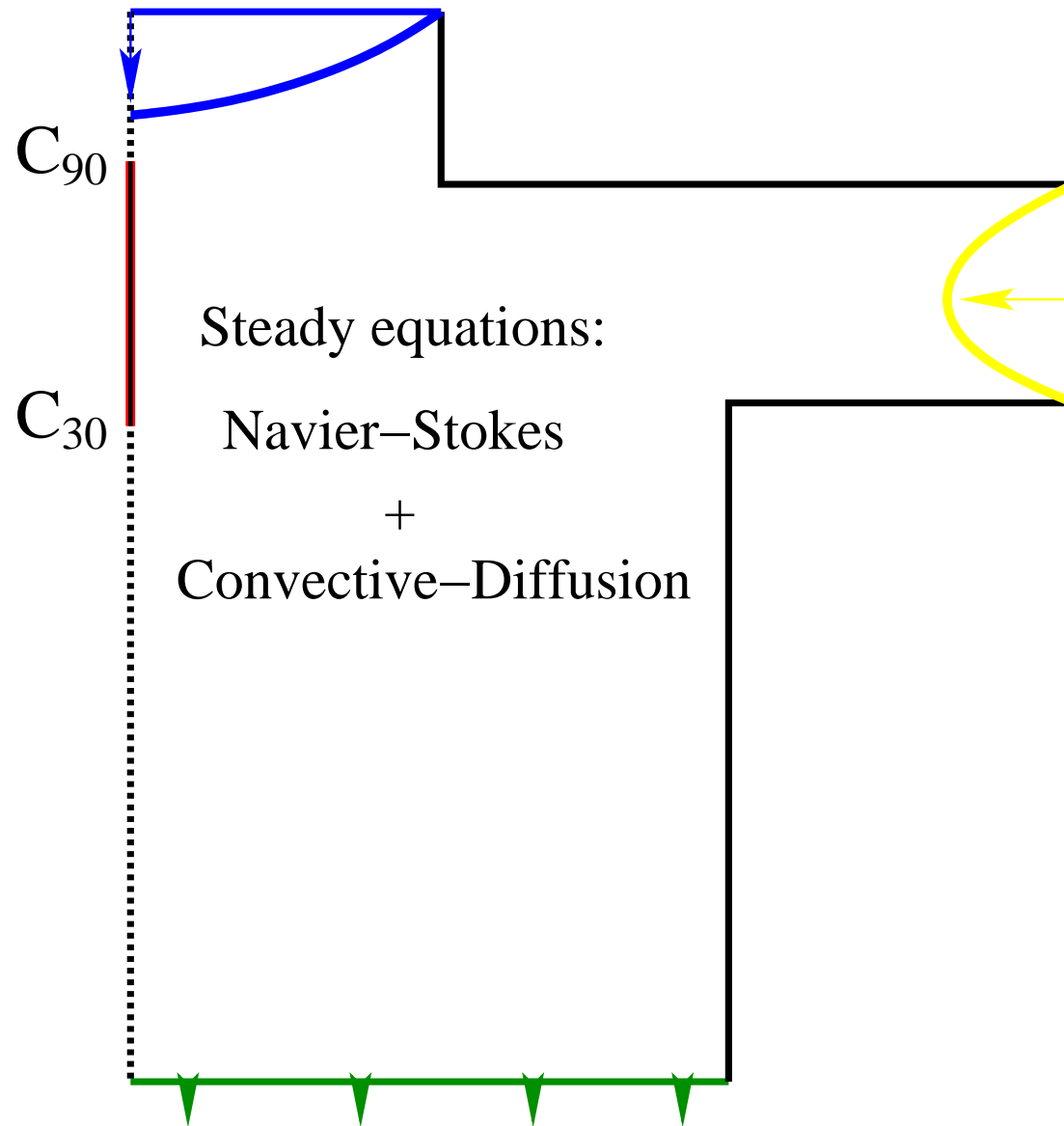
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Design Problem

We are interested in minimizing:

$$J(x_{\text{param}}) = \int_{c_{90}^{x_{\text{param}}}}^{c_{30}^{x_{\text{param}}}} \frac{dy}{\mathbf{u}^{x_{\text{param}}}(y) \cdot t},$$

where $c_{90}^{x_{\text{param}}}$, $c_{30}^{x_{\text{param}}}$ and $\mathbf{u}^{x_{\text{param}}}$ are computed by solving numerically (**COMSOL**) the following system:

$$\begin{cases} -\nabla \cdot (\eta(\nabla \mathbf{u} + (\nabla \mathbf{u})^\top)) + \rho(\mathbf{u} \cdot \nabla) \mathbf{u} + \nabla p = 0 & \text{in } \Omega, \\ \nabla \cdot \mathbf{u} = 0 & \text{in } \Omega, \\ \nabla \cdot (-D \nabla c + c \mathbf{u}) = 0 & \text{in } \Omega, \\ + \text{boundary conditions.} \end{cases}$$

This optimization problem is solved by using the **Global Optimization Platform** software (**MATLAB**):

<http://www.mat.ucm.es/momat/software.htm>

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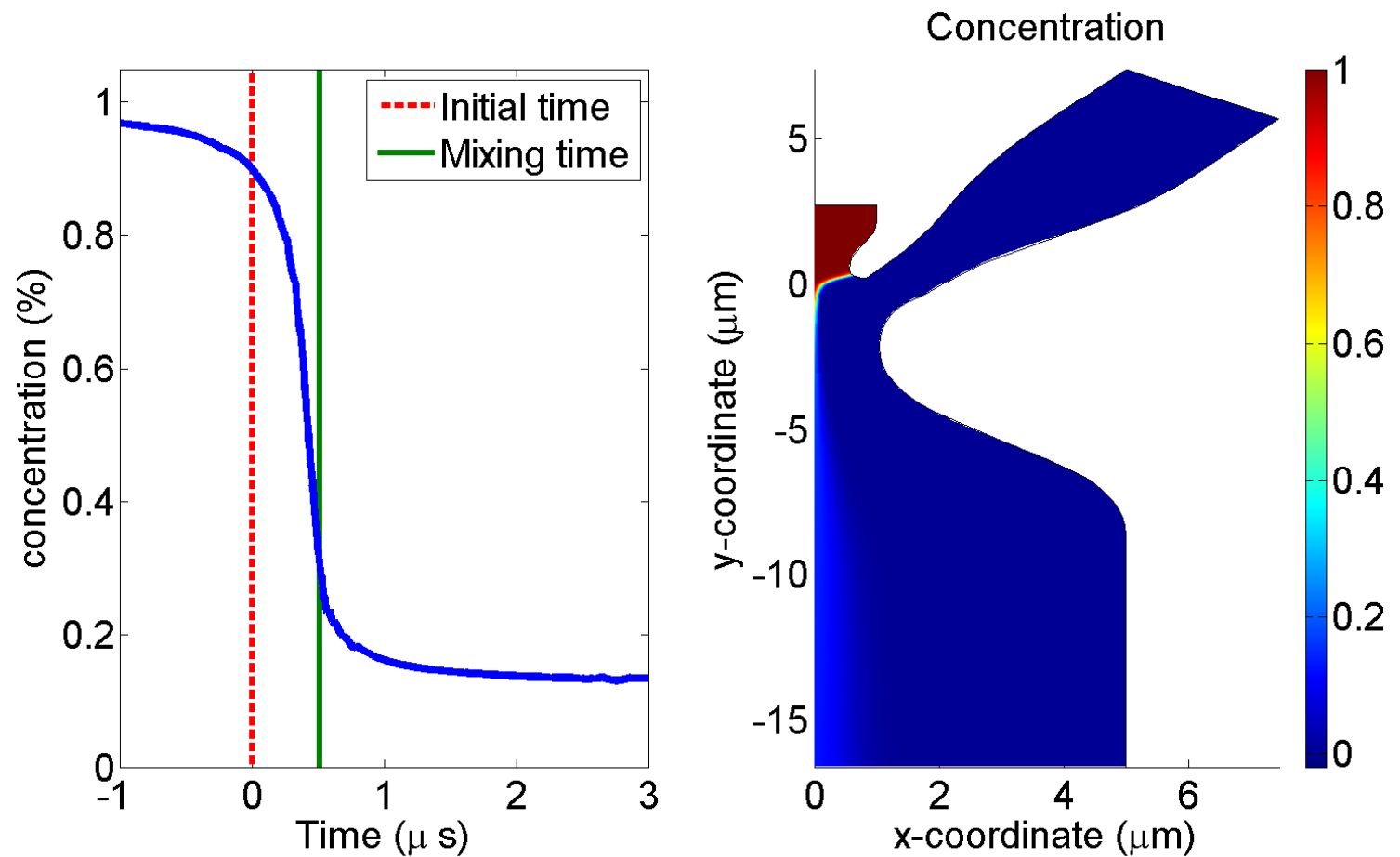
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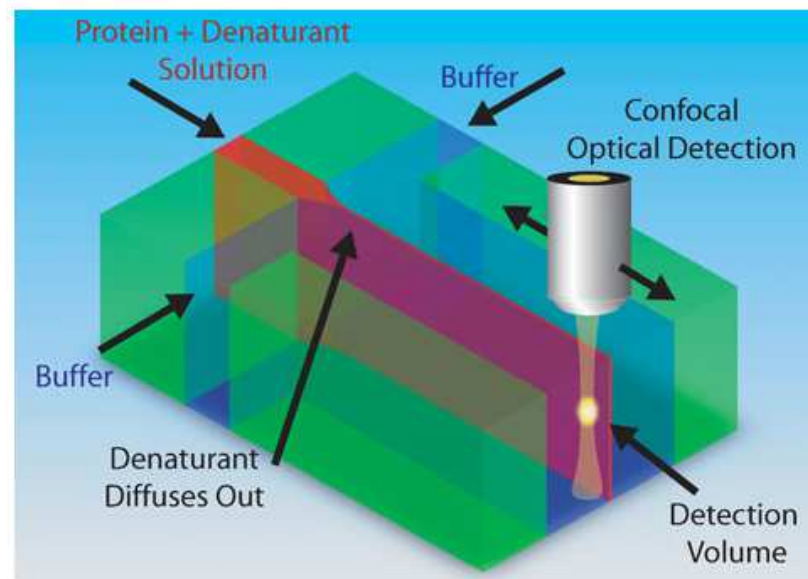
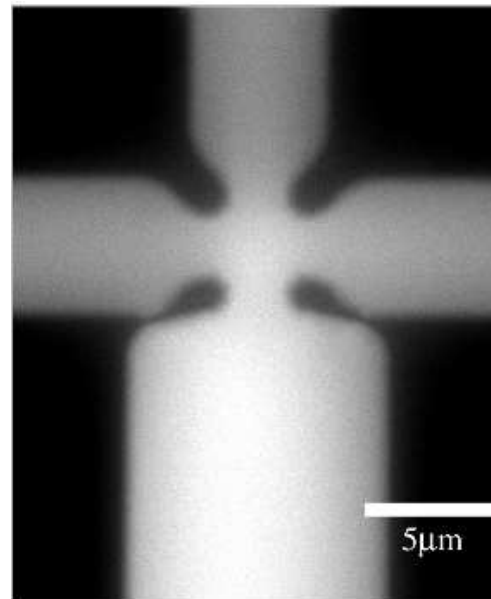
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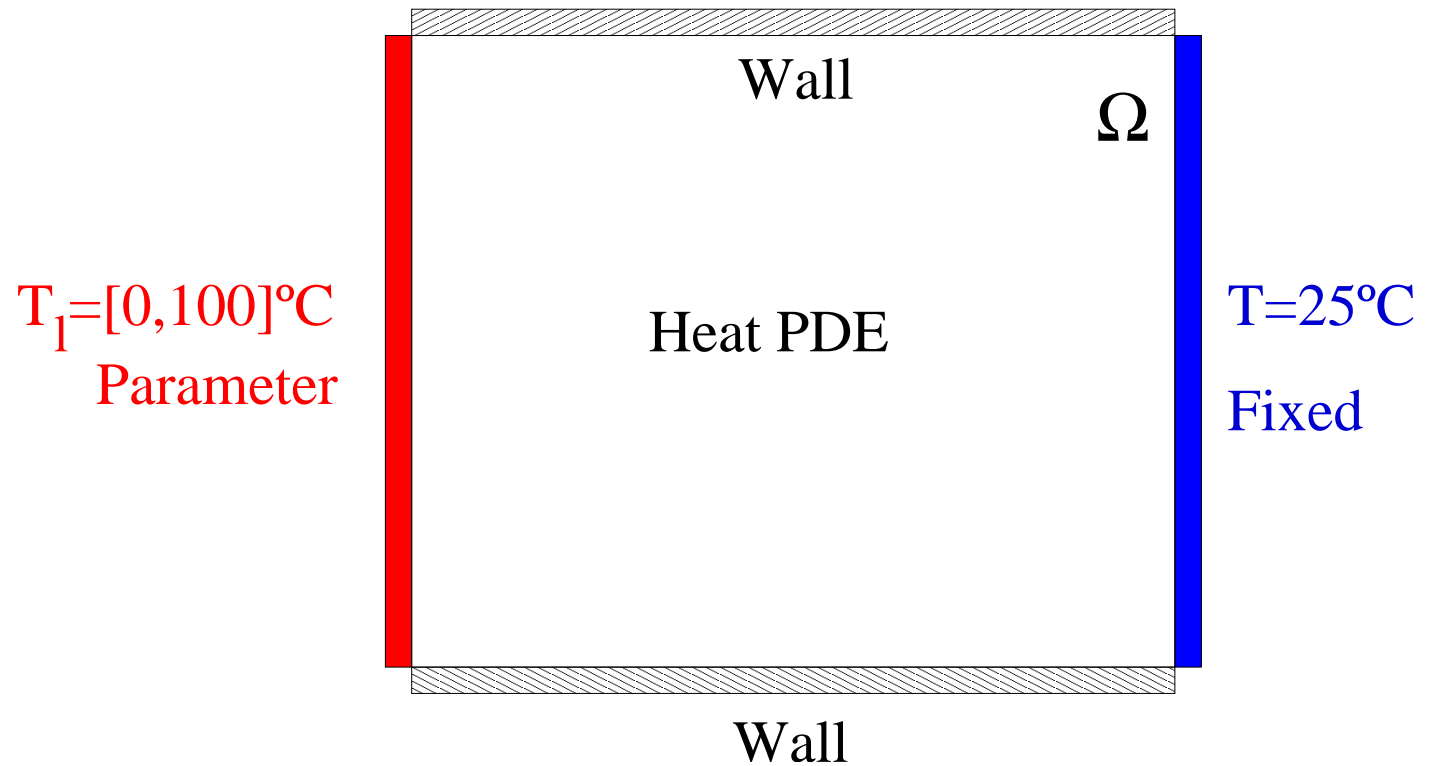
Conclusions

- Benjamin Ivorra, Juana Redondo, Juan Santiago, Pilar Ortigosa, and Angel Ramos. *Two- and three-dimensional modeling and optimization applied to the design of a fast hydrodynamic focusing microfluidic mixer for protein folding*. Physics of Fluids, 25, 032001, 2013.
- David E. Hertzog, Benjamin Ivorra, Bijan Mohammadi, Olgica Bakajin, Juan G. Santiago. *Optimization of a Fast Microfluidic Mixer for Studying Protein Folding Kinetics*. Analytical chemistry, 78(13), 4299-4306, 2006.
- Benjamin Ivorra, David E. Hertzog, Bijan Mohammadi, Juan G. Santiago. *Semi-deterministic and genetic algorithms for global optimization of microfluidic protein-folding devices*. International Journal for Numerical Methods in Engineering , 66(2), 319-333, 2006.

Toy problem

We want to **optimize** the **temperature** of the left wall (T_l) of a given rectangular heat chamber such that the **mean spatial temperature is 50°C**:

$$\min_{T_l \in [0,100]} J(T_l) = \left| \left(\int_{\Omega} T(T_l) dx / \int_{\Omega} 1 dx \right) - 50 \right|$$



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Main steps

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- Use the **COMSOL GUI** to easily **create** the model.
- **Identify and isolate** all the parameters to be modified by the MATLAB code.
- **Compress history** before exporting the model to MATLAB format.

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- `mphgeom(model,'geom1')`
- `mphmesh(model,'mesh1')`
- `model.result.table('tbl1').getReal`
- `mphint(model,'u','T',tf,'edim',2,'selection',[1])`
- `mphinterp(model,'u','T',tf,'coord',[0.2;0.2])`
- `mphsave(model,'optimum')`
- `model=mphload('optimum')`
- `model.variable('var1').set('Tmax', num2str(x(1)))`

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- Course (10H): Método de Elementos Finitos: Aplicaciones y Optimización con COMSOL MULTIPHYSICS. Doctorado en Ingeniería Matemática, Estadística e Investigación Operativa. **Universidad Complutense de Madrid.** February.
- Seminary (2H): Simulación numérica en Ingeniería y Ciencias con MATLAB + COMSOL Multiphysics. Departamento de Física Aplicada II y Vicerrectorado de Investigación. **Universidad de Málaga.** May.



Google keywords: Ivorra Benjamin Researchgate

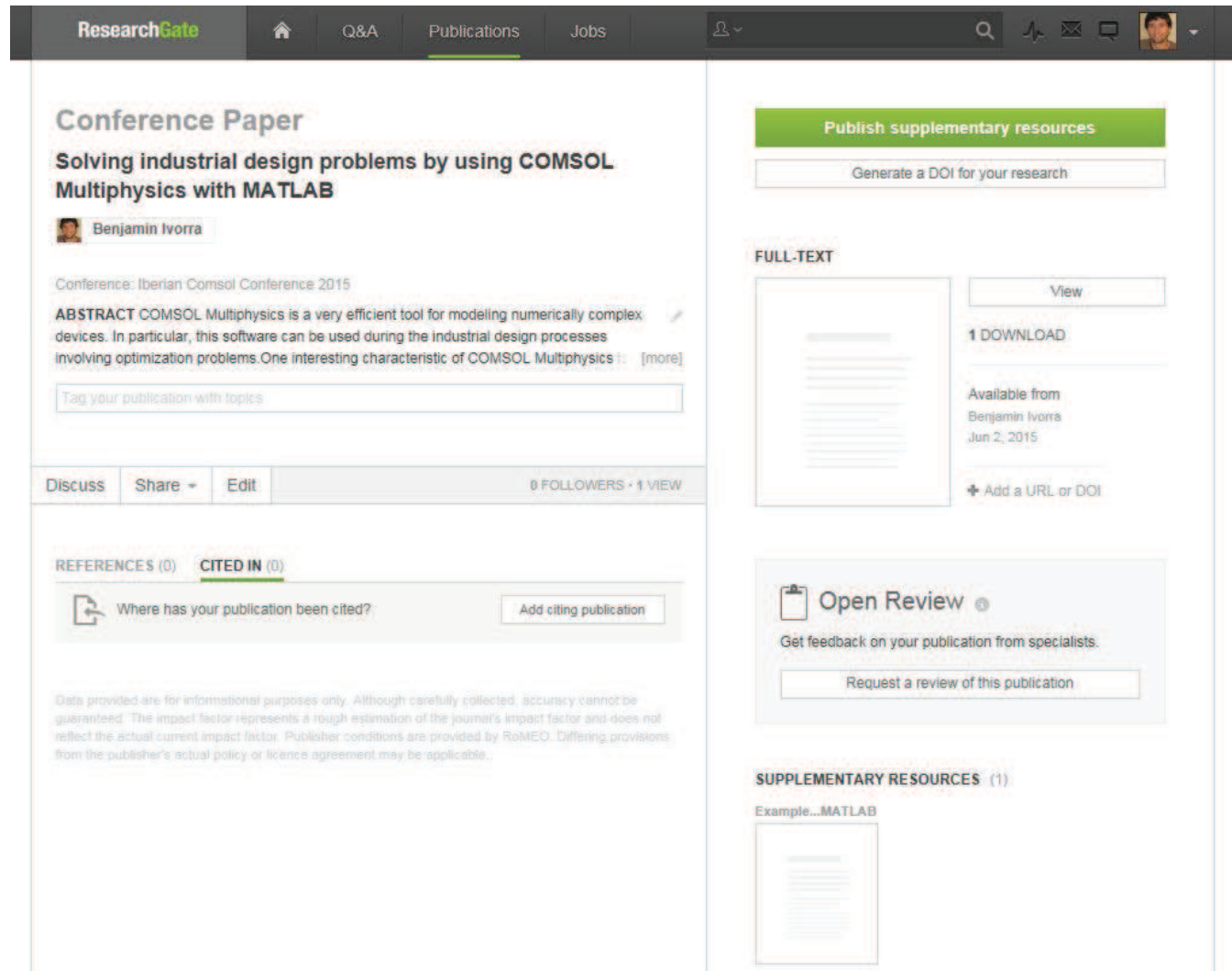
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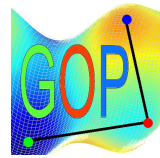
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The screenshot shows a ResearchGate profile page for Benjamin Ivorra. The page title is "Conference Paper" and the subtitle is "Solving industrial design problems by using COMSOL Multiphysics with MATLAB". The author's name is Benjamin Ivorra. The conference is listed as "Iberian Comsol Conference 2015". The abstract states: "COMSOL Multiphysics is a very efficient tool for modeling numerically complex devices. In particular, this software can be used during the industrial design processes involving optimization problems. One interesting characteristic of COMSOL Multiphysics is: [more]". There is a "Tag your publication with topics" input field. The page has a "Discuss" button, a "Share" button, and an "Edit" button. It shows "0 FOLLOWERS" and "1 VIEW". The "REFERENCES (0)" and "CITED IN (0)" sections are empty. There is a "Where has your publication been cited?" section with an "Add citing publication" button. A disclaimer at the bottom states: "Data provided are for informational purposes only. Although carefully collected, accuracy cannot be guaranteed. The impact factor represents a rough estimation of the journal's impact factor and does not reflect the actual current impact factor. Publisher conditions are provided by RoMEO. Differing provisions from the publisher's actual policy or licence agreement may be applicable." On the right side, there is a "Publish supplementary resources" button, a "Generate a DOI for your research" button, a "FULL-TEXT" section with a "View" button, "1 DOWNLOAD", "Available from Benjamin Ivorra Jun 2, 2015", and a "Request a review of this publication" button. There is also a "SUPPLEMENTARY RESOURCES (1)" section with a link to "Example...MATLAB".

!!! Thank you for your attention!!!



Global Optimization Platform

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